Dolby®

MODEL CP45
CINEMA PROCESSOR
Users' Manual

USERS' MANUAL

FOR

MODEL CP45 CINEMA PROCESSOR

Dolby Laboratories Inc

U.S.A. 100 Potrero Avenue, San Francisco, CA 94103
Tel: 415-558-0200; Fax: 415-863-1373

U.K. Wootton Bassett, Wiltshire SN4 8QJ, England
Tel: 01793-842100; Fax: 01793-842101

Dolby is a registered trademark of Dolby Laboratories Licensing Corporation.

©1995 Dolby Laboratories

ISSUE 1
S95/10750
Dolby Part No. 91388

TABLE OF CONTENTS

INTRODUCTION

SECTION 1
OPERATING INSTRUCTIONS 1-1

A. NORMAL OPERATION
1. Initial Power-Up 1-1
2. Format Selection 1-1
3. Local (Front-Panel) Fader 1-3
4. Remote Faders 1-3
5. Mute Function 1-3

B. OPERATION WITH AUTOMATION SYSTEM 1-4
C. BYPASS OPERATION 1-4

SECTION 2
MAINTENANCE AND ADJUSTMENTS 2-1

A. SOUNDHEAD MAINTENANCE 2-1
B. PRINT CLEANLINESS 2-2
C. DOLBY LEVEL ADJUSTMENT 2-2

SECTION 3
TROUBLESHOOTING 3-1

A. DURING THE SHOW
1. If Film Sound Is Lost 3-1
2. If One Channel Fails or is Distorted 3-2
3. If Switching to Bypass Does Not Restore Sound 3-2
4. Excessive or Inappropriate Sound from the Surround Speakers 3-3

B. BETWEEN SHOWS 3-3

C. WHEN THE THEATRE IS CLOSED 3-4

D. TROUBLESHOOTING CHART 3-6

APPENDIX A
HOW TO TELL A STEREO OPTICAL PRINT
FROM A MONO PRINT A-1

APPENDIX B
DOLBY TEST AND DEMONSTRATION FILMS B-1
1. Cat. No.69T: Dolby Tone B-1
2. Cat. No.251: Jiffy Test Film B-1
3. Cat. No.351 Stereo Demonstration Film: “listen . . .” B-3
4. Other Test Films B-3

APPENDIX C
CP45 MODULE DESCRIPTIONS C-1

APPENDIX D
ABOUT DOLBY FILM SOUND FORMATS D-1
1. How Dolby Noise Reduction Works D-1
2. About Dolby SR D-1
3. Why the Dolby Level Adjustment Is Important D-3
4. The Consumer Dolby Noise Reduction Systems D-3

APPENDIX E
HOW FOUR CHANNELS ARE DERIVED FROM
DOLBY STEREO OPTICAL PRINTS E-1

APPENDIX F
OPTICAL BASS EXTENSION F-1

APPENDIX G
CINEMA SOUND AND THE EVOLUTION
OF DOLBY FILM SOUND G-1

INTRODUCTION

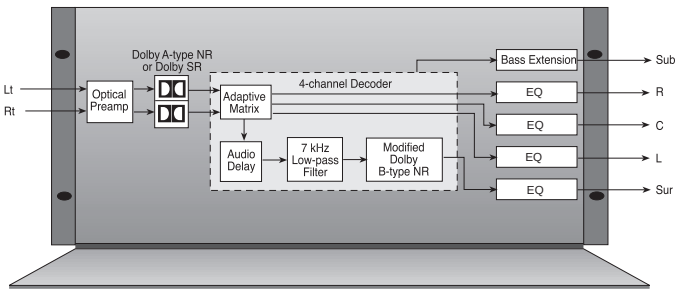
WHY A CINEMA PROCESSOR?

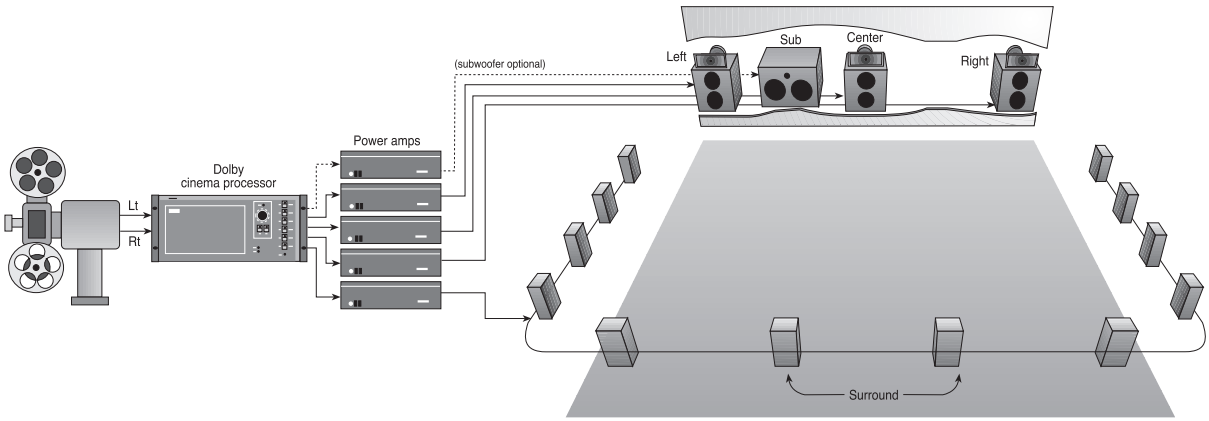
Originally, stereo sound on motion picture film was possible only by means of magnetic striping, which was introduced in the 1950s. Although capable of very good sound, this was such a costly approach that by the 1970s relatively few films were being released with stereo soundtracks.

Then in 1975 Dolby Laboratories introduced the stereo optical soundtrack originally known as Dolby Stereo. It provided the multichannel sound associated with magnetic soundtracks in a much more practical format.

Getting high-quality stereo sound from an optical soundtrack required the application of several new processes. It was necessary, for example, to electronically "fold" four sound channels into just two physical tracks on the film, and then "unfold" (decode) them on playback in the theatre. Dolby noise reduction, a form of signal processing that greatly expands the limited dynamic range of optical soundtracks, was also used, and requires its own special playback processing circuitry.

Thus the cinema processor was introduced as a new element in theatre sound systems. In addition to properly decoding Dolby encoded soundtracks, Dolby processors such as the CP45 also provide equalization circuits that optimize the frequency range of the projector's optical soundhead and the theatre loudspeakers. The diagrams below show the role cinema processor plays in bringing your audiences thrilling, multichannel Dolby sound.





About The Dolby CP45

Once installed, the Dolby CP45 Cinema Processor becomes the heart of your theatre sound system. All sound sources are connected to the CP45, which processes their signals appropriately and feeds them to the power amplifiers.

The Dolby Model CP45 provides the high performance for which all processors manufactured by Dolby Laboratories are known in a new cost-effective, integrated design. Its many features include a stereo optical preamp with precise slit-loss correction, processing for both Dolby A-type and Dolby SR soundtracks, an advanced 2:4-channel decoder, and multi-band screen speaker equalization. These advanced circuits ensure accurate reproduction of all films with Dolby analog soundtracks, and permit the theatre to use the widely-respected name "Dolby" on the marquee and in advertising to identify presentations of Dolby releases.

Additional standard features of the CP45 are a built-in fader with remote facilities, simple push-button soundtrack format selection, and comprehensive fail-safe features that include a built-in bypass system. The unit also interfaces readily with theatre automation systems.

The CP45 supports the following sound formats:

Format	**Number**
Mono	01
Dolby A-type (stereo)	04
Dolby SR (stereo)	05
Non sync 1	60
Non sync 2 / Aux	61
Microphone	64

About This Manual

This Users' Manual has been prepared specifically to help projectionists get the most from the Model CP45 and the theatre sound system once it has been installed and aligned. (Installation and alignment instructions are supplied to the local distributor or installation company). We suggest that you keep this manual readily available.

The manual is organized as follows:

- Section 1, Operating Instructions, covers the basic control functions and operation of the CP45.

- Section 2, Maintenance and Adjustments, contains tips for maintaining the CP45 and the theatre sound system.

- Section 3, Troubleshooting, will help you track down problems in the sound system without test equipment. It consists of a troubleshooting chart and procedures to follow during a show, between shows, and after closing.

- The Appendices contain valuable background information which will help you to get the most out of the Model CP45 and your theatre sound system.

For the sake of clarity, boldface type is used for all specific references to the CP45 controls and their labels, such as Bypass, and front-panel Fader. In addition, indicator lights on the CP45 are referred to in the text as LEDs (light-emitting diodes).

SECTION 1
OPERATING INSTRUCTIONS

A. NORMAL OPERATION

1. Initial Power-Up

Each time the CP45 is connected to power, it automatically sets itself to the format it was in when power was removed unless the power has been removed for more than a week. Under these circumstances the wake-up state is:

- Format **01 Mono**
- Front-panel (Local) fader activated
- **Proj 1** or **Proj 2** LED illuminated, indicating the externally-selected projector that is active (Proj 1 can be set to be selected automatically if no external selection has been made although it is usual for the individual projectors to be selected for bypass mode flexibility).

2. Format Selection

Select the desired film soundtrack format or your non-sync source by pressing the appropriate button. The LED in the button illuminates to confirm that the format was selected. The formats are as follows:

- **01 Mono**: for all optical prints of any vintage with conventional mono optical ("Academy") soundtracks.
- **04 Dolby A-type**: for Dolby Stereo releases, except those marked SR or Digital.
- **05 Dolby SR**: for releases marked as having a Dolby SR soundtrack. (If your CP45 is not equipped with the SR circuit needed to play SR copies, 04 Dolby A-type can be selected.)
- **60 Non-sync 1**: for your music tape or CD player.
- **61 Aux/Non-sync 2**: this format may be programmed in a number of different ways depending on the optional equipment fitted and the installation. Possible options include:

  Magnetic soundtracks from projectors or followers with appropriate magnetic preamplifiers.

  Extra sound sources (consult your service engineer for details).

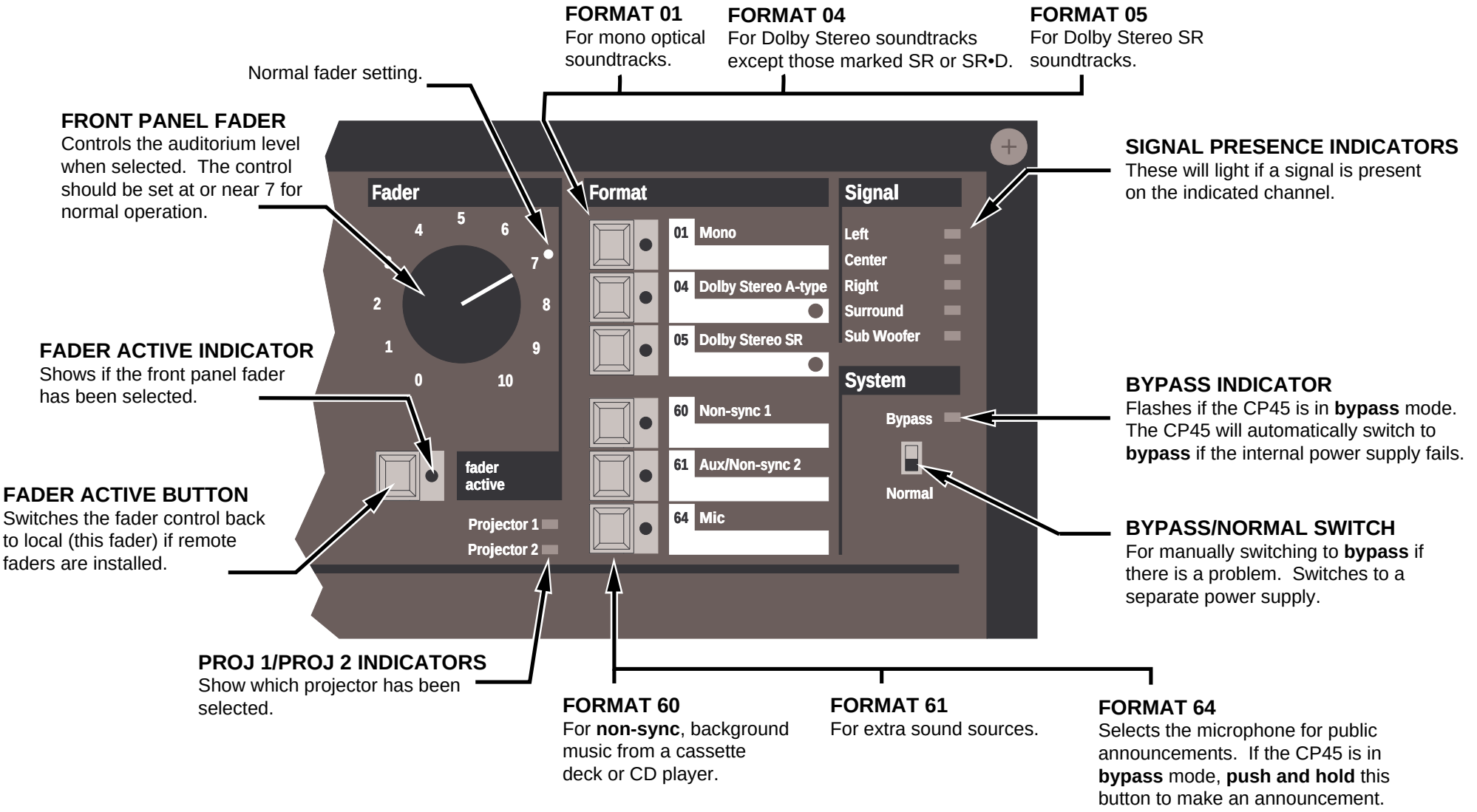

FORMAT 01
For mono optical soundtracks.
FORMAT 04
For Dolby Stereo soundtracks except those marked SR or SR•D.
FORMAT 05
For Dolby Stereo SR soundtracks.
Normal fader setting.
FRONT PANEL FADER
Controls the auditorium level when selected. The control should be set at or near 7 for normal operation.
SIGNAL PRESENCE INDICATORS
These will light if a signal is present on the indicated channel.
Fader
Format
Signal
01 Mono
04 Dolby Stereo A-type
05 Dolby Stereo SR
Left
Center
Right
Surround
Sub Woofer
System
Bypass
Normal
60 Non-sync 1
61 Aux/Non-sync 2
64 Mic
fader active
Projector 1
Projector 2
FADER ACTIVE INDICATOR
Shows if the front panel fader has been selected.
BYPASS INDICATOR
Flashes if the CP45 is in bypass mode. The CP45 will automatically switch to bypass if the internal power supply fails.
FADER ACTIVE BUTTON
Switches the fader control back to local (this fader) if remote faders are installed.
BYPASS/NORMAL SWITCH
For manually switching to bypass if there is a problem. Switches to a separate power supply.
PROJ 1/PROJ 2 INDICATORS
Show which projector has been selected.
FORMAT 60
For non-sync, background music from a cassette deck or CD player.
FORMAT 61
For extra sound sources.
FORMAT 64
Selects the microphone for public announcements. If the CP45 is in bypass mode, push and hold this button to make an announcement.

Figure 1. CP45 Front Panel Control

- **64 Mic**: for public address announcements in the theatre.

The film soundtrack format numbers used on the CP45 front panel often appear on the film can and leader. If these numbers are not supplied and you are not sure if a print is mono or stereo optical, see Appendix A for a means to distinguish mono from stereo optical soundtracks.

If you are playing an early Dolby Stereo release and it is marked as format 03 "Dolby Stereo without surround," select format **04 Dolby A-type**.

3. Front Panel (Local) Fader

The fader on the front panel of the CP45 controls the volume level in the theatre in all operating modes. After the CP45 has been correctly installed, setting the fader to 7 will play a Dolby film at the level at which it was mixed.

Although a minor adjustment in playback level might be required under unusual circumstances, you should avoid significant deviations from the correct level (7) established by the installer. If the playback level is set too low, dialogue will be hard to understand; too high a level will give rise to complaints from the audience and under extreme circumstances can damage the theatre's sound system.

4. Remote Faders

In addition to the front panel (local) fader the CP45 can also be controlled by an external remote fader.

If a remote fader has been installed, it is activated by pressing the select button on the remote. The local front panel fader LED will go off to indicate that the remote fader has been activated. To regain local control, press the "fader active" button located below the front panel fader. The button will have no effect if there are no remote faders.

5. Mute Function

When you press the mute button on the remote unit (if installed), the volume will automatically fade all the way down. When you press the button again, the volume will automatically rise to the level set by the fader which is in control of the level (local or remote fader).

The Mute button is useful if the film breaks or runs out with the projector active since it supresses the very loud signal that occurs when a leader or tail passes through the sound gate.

If the CP45 is not conveniently close to the projector and there is a remote fader at the projector, use the following procedure to start the show:

- Fade out the intermission music with the local front panel fader.
- Move to the remote location and see that the fader there is at 7.
- Select the film format.
- Start the projector.
- After the film leader has passed through the gate, select the remote fader and trim the level slowly if necessary.

Following the above procedure should prevent the audience from hearing annoying thumps and leader crackle at the beginning of the show.

B. OPERATION WITH AUTOMATION SYSTEMS

If the CP45 in your theatre is connected to automation equipment, the format buttons and their associated LEDs may be duplicated elsewhere. In most cases, the front panel controls of the CP45 can usually be used to override commands from the automation system; however, as automation equipment differs from installation to installation, check with the installer of your system if you have any questions about its operation and whether you can easily override automation commands.

C. BYPASS OPERATION

The CP45 has an independent power supply for emergency operation. If the main power supply or processor circuitry fails, the unit will automatically switch to bypass operation, allowing the show to continue with limited sound processing functions. Bypass operation is signalled by the flashing of the bypass LED on the front panel.

In the case of other problems, such as distortion or the loss of a channel, the bypass mode can be selected manually by means of a switch located on the front panel. However, there are other components in the theatre sound system that could also fail. Be sure to refer to **Section3, Troubleshooting**, any time there is a problem.

The following occurs when the CP45 is switched into the bypass mode:

- The front-panel remains operational but **remote faders will not work**.
- Although you can select formats to help with faultfinding, the commands from the front panel are ignored by the unit. The optical preamp output of the selected projector and (if so programmed at installation) the Non-sync and / or Aux inputs all remain operational simultaneously. If you are not playing film,

be sure that the projector is not selected. If you are playing an optical film print, be sure that there are no signals present from any of the other sound sources.

- Even when a stereo print is playing, a summed **mono** signal is fed to all the screen speakers. Thus, you can switch to the bypass mode to keep the show going if one of the power amplifiers or speakers fail.

- The Dolby A-type noise reduction circuitry, Spectral Recording processors, 2:4-channel decoder, screen speaker equalizers, surround equalizers, and subwoofer circuits are out of the signal path.

- The front panel mic switch acts as a "push to talk" key rather than a "push on, push off" switch. If there are emergency announcements to make, the film and background music should be turned off so that the audience can hear the announcement above the other sources of sound.

If the unit has entered bypass mode due to a failure in the main power supply or the main power source, then the front panel LEDs will be off except the projector select and bypass LEDs. The unit performs in exactly the same way as if the bypass switch were selected as described above.

In the event of bypass operation, be sure to follow the troubleshooting procedures and call your trained service engineer, if necessary, as soon as possible.

NOTE

The CP45 will not operate even in the bypass mode if there is a fault in the mains supply to the bypass transformer and may not operate if there is a fault in either the Cat. No. 514 optical preamp card, the bypass circuitry section of the Cat. No. 510 on which it is mounted, or the bypass power transformer itself. It is strongly recommended that a spare of both of the cards and the transformer block be kept on hand for substitution in emergencies. If the theatre is equipped with film platters and the unused projector input on the rear of the CP45 is accessible, the projector solar cell leads can be moved from P1 to P2 in order to try using the second optical preamp circuit, however this input may not be set up correctly so care will be needed with the volume control.

WARNING

The CP45 was adjusted initially by a specially-trained engineer so that your theatre would have the same standard playback characteristics as the dubbing theatres in which all Dolby encoded films are mixed. This results in the most accurate reproduction possible. **Never attempt to adjust any controls within the CP45 except those specified in this manual.**

All other controls are for use by a trained engineer when the CP45 is first installed or repaired. Adjusting these controls requires the use of special test equipment. Misadjusting these controls can have an adverse effect on the sound in your theatre and will require a service call to restore proper operation. The first thing to do when you have a problem is to consult Section 3 **Troubleshooting**, and not randomly adjust these specialized controls.

In addition, do not adjust any of the controls on the other audio equipment in your theatre sound system such as power amplifiers, which have been preset by the installer. For example, misadjusting the power amplifier gain controls can cause channel imbalance and / or too much power amplifier noise. Those controls have been set by the installer for correct channel balance and so that the playback level in the theatre is correct with the **fader** set to 7. If a satisfactory level can only be achieved with the **fader** set to some other level, the gain controls on the power amplifiers have been touched and have now to be recalibrated by a service engineer.

SECTION 2
MAINTENANCE AND ADJUSTMENTS

The installation of the Dolby CP45 in your theatre indicates a commitment to providing a high-quality presentation to your audiences. However, the presence of even the very best equipment does not in itself guarantee the best results. A number of routine maintenance and adjustment procedures, requiring no special test equipment or technical knowledge, are necessary to realize the full potential of the sound system on a day-to-day basis. These procedures can also prevent costly show cancellations and service calls.

A Dolby Cat. No. 69T test film is required for proper maintenance of your sound system. We also recommend that you keep on hand the Dolby Cat. No.251 Jiffy Test Film and run it regularly to check the theatre sound system thoroughly (see Appendix B).

A. SOUNDHEAD MAINTENANCE

No single maintenance procedure is more vital to good sound in the theatre than regular cleaning of the projector soundhead optics. Use lint-free cotton swabs and isopropyl alcohol to clean the optical barrel lens surfaces, but, under no circumstances touch or attempt to clean the solar cell. The solar cell and its adjustment are extremely delicate. We strongly recommend that you use compressed air, available in convenient pressure cans, to blow dirt and debris away from the cell. But be absolutely certain that the nozzle cannot ever touch the cell.

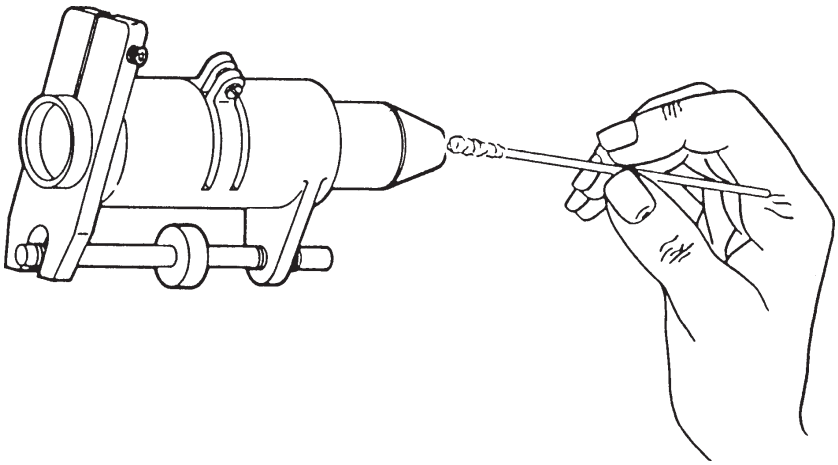


Figure 1 Cleaning the Soundhead Optics

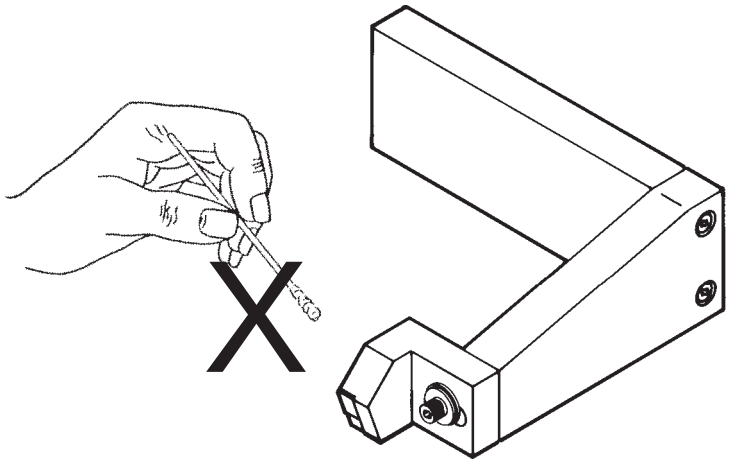


Figure 2 Never touch the solar cell

B. PRINT CLEANLINESS

A high fidelity Dolby Stereo theatre system is like a high-quality home stereo system: it can sound only as good as the program material played through it. A good theatre system will reproduce pops, crackles, and other unwanted noises from worn and dirty film prints.

If you receive a poor print from your distributor, there is little you can do except, if possible, arrange for its replacement. But while a print is in your theatre, you should treat it with respect and care to be sure your audiences receive the best in both sound and picture. Of greatest importance, the print should be kept as clean as possible—when the film is played, when the print is stored between shows, and when a platter reel is made up (if your theatre is so equipped). In particular, when individual reels are unwound to make up a platter reel, **do not let the film touch the floor** or come in contact with other sources of dust and dirt.

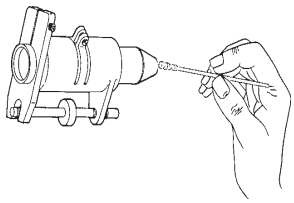
C. DOLBY LEVEL ADJUSTMENT

Proper decoding of soundtracks encoded with Dolby A-type or SR processors requires careful level matching between each channel of each soundhead and the CP45 (see Appendix D for a discussion of Dolby noise reduction and why Dolby Level is important). When the CP45 is first installed, the installer makes this adjustment for you. However, **it is always necessary to adjust Dolby Level whenever an exciter lamp is replaced**. We also recommend that you routinely check Dolby Level but only adjust it to compensate for the normal aging of the exciter lamp if necessary. Always clean the optics first.

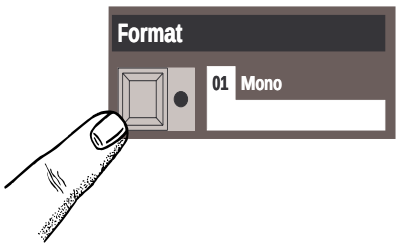
Checking and adjusting Dolby Level requires a loop of Dolby Cat. No. 69T test film that is available from your theatre equipment supplier. You will also need the alignment tool supplied with the CP45 or a small screwdriver.

The adjustment procedure is as follows:

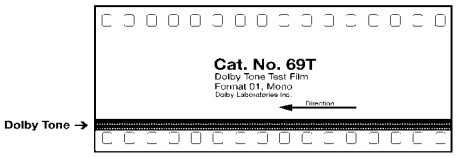
1. Clean the soundhead optics (see part A above).



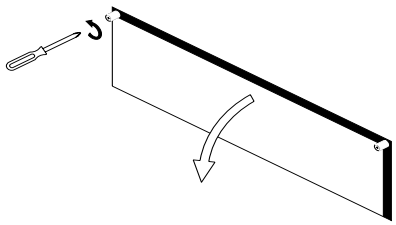
2. Select format 01 **Mono**.



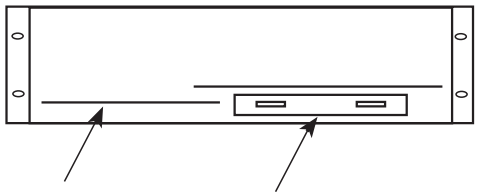
3. Thread the loop of Dolby Cat. No. 69T test film on the projector and play the Dolby Level tone (with its characteristic warble). Be sure that the emulsion side of the film faces towards the projector exciter lamp. The film must run in the direction of the printed arrow.



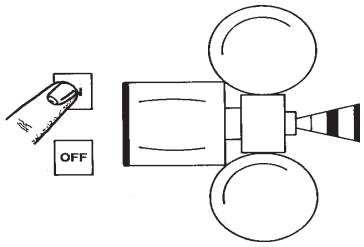
4. Open the front panel of the CP45 using a screwdriver.



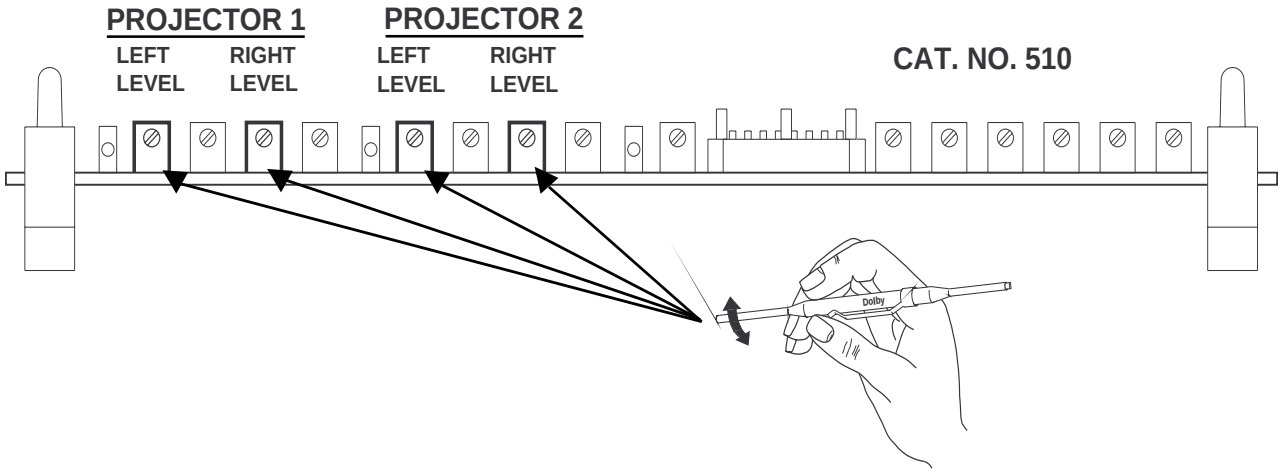
5. Locate the Cat. No. 510 card and Cat. No. 222 noise reduction module. (Dolby Level adjustments are made on the Cat. No. 510 while the LEDs on the Cat. No. 222 module indicate when Dolby level is achieved.)

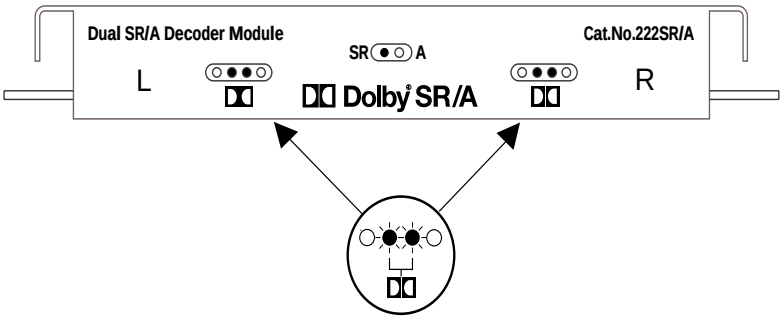


6. Turn the projector on.



7. As the test loop is played, watch the LEDs on the Cat. No. 222A / SR. Correct Dolby Level is indicated when the two center green LEDs for each channel are equally bright. If necessary, adjust the Left and / or Right **gain** controls (mounted on the front edge of the Cat. No. 510) for the projector in use so that the pair of green LEDs is equally lit. Be very careful not to adjust the adjacent, recessed **hf** control by mistake; **if this control is inadvertently changed, a service engineer with special test equipment is required to readjust it**.





8. Repeat the above procedure for the other projector.

NOTE

If you happen to play the test film with a stereo optical format (04 or 05) selected after Dolby Level has been correctly adjusted, you may notice that the pairs of green LEDs are not equally lit or that one or both of the left hand side LEDs goes out completely. This is normal, and represents a very small (less than 0.5 dB) level difference when the Dolby noise reduction circuitry is switched on for the stereo formats.

SECTION 3
TROUBLESHOOTING

Your theatre sound system consists of a number of critical audio components in addition to the Dolby CP45. Thus, the first step when something goes wrong with the sound is to find the source of the problem. The troubleshooting chart starting on page 3-6 can be helpful.

If the troubleshooting chart is not sufficient for finding and solving the problem right away, the procedures in the following paragraphs should be helpful. Each paragraph is gauged to the time available for troubleshooting; during a show, between shows, and after closing. In addition, Appendix C contains brief descriptions of each circuit module, which will further help you to track down any problems with the CP45.

If you are unable to solve the problem using the information which follows, call your local authorized service engineer.

A. DURING THE SHOW

1. If Film Sound Is Lost

- Check that the correct projector is selected.
- Check to see if the exiter lamp on the active projector is on.
- Check to make sure that the power amps are on.
- Immediately switch the CP45 to bypass. (Push up the small slide switch on the right hand side of the front panel under the green signal present indicators). If sound is restored, troubleshooting can be performed later.
- Check to see if *any* of the LED's on the front panel are on. If no front panel LED's are on, the processor has lost all power. Find out why immediately. Check if anything else has lost power.
- Disconnect mains transformer blocks from the wall socket / outlet. Re-connect to a different socket / outlet powered by a different mains circuit.
- If there are now at least two LEDs on, (a projector indicator and bypass flashing) and sound does come back on, it will be mono but you can continue the show while you try to find the source of the trouble.

- If you know why power was lost and is now back, (there is one or more LEDs alight in the pushbuttons) check that the format is appropriate and switch the CP45 out of bypass. The unit will stay in bypass for about 5 seconds then revert to the format on the front panel.

- If you don't know why power was lost keep the unit in bypass until you can find the reason.

- Be sure that the correct projector and format are selected.

- Check to see if both mains transformer blocks are plugged in securely to a live outlet.

- If these checks do not restore the sound, and there is at least one front panel LED on, put up the theatre lights and play your source of music. If you are not in bypass, switch to format 60 non-sync first. If the system operates properly in this format, there is no problem with the equipment following the CP45 in the system (such as amplifiers and speakers) and the problem may well be in the projectors. Double-check both projectors and continue the show on a working projector if you find that one projector is at fault.

2. If One Channel Fails or is Distorted

Switch the CP45 to bypass; a mono signal is then fed to all three screen channels. If the distortion persists in one channel, the power amplifier or speaker for that channel is probably at fault and the amplifier for that channel should be switched off for the remainder of the show. If the left channel has failed, also switch off the amplifier for the right channel, so that only the center channel is in operation. (If the right channel has failed, also switch off the amplifier to the left channel.)

If you are showing a mono film and the center channel fails or is distorted, switch the CP45 to bypass so that the mono signal is fed to the undistorted left and right channels. In this case, turn off the power amplifier for the center channel.

3. If Switching to Bypass Does Not Restore Sound

- First, check the exciter lamps, the position of all faders and the remote mute button. Make certain that all components including power amps are receiving AC power.

- Turn the **fader** down.

- Check the bypass LED on the CP45; it should be flashing, indicating that the CP45 switched to the bypass mode. If it is not flashing and you are absolutely certain that AC power is reaching both the

CP45 transformers, the bypass transformer wires must have come unscrewed from the back panel connections or, (this is very unlikely) the transformer has failed internally.

- If you have a spare Cat. No. 514 optical preamp module, switch off the power amps and processor and replace the Cat. No.514 in the CP45 with the spare. Switch the power amps back on and check if sound is restored.

- If replacing the Cat. No.514 does not restore sound in the bypass mode, the bypass circuitry within the Cat. No.510 circuit card may have failed. If you have a spare, disconnect power from the CP45, switch off the power amplifiers, and replace the Cat. No.510 in the CP45 with the spare. Apply power to the CP45 and turn on the power amps to see if sound is restored.

4. Excessive or Inappropriate Sound from the Surround Speakers

As an emergency measure to continue the show, switch off the surround channel amplifiers. At your next opportunity, find out if the problem is related to the film print itself or the theatre sound system.

- If the film sound was mixed to include surround information, as are the vast majority of Dolby encoded films, the problem may be in;

    a. The sound system (speakers, power amps), or

    b. The alignment of the solar cell in the projector, or

    c. The Cat. No.514 optical preamp, or

    d. The Cat. No.511 main board decoder section.

  Continue the show with the surround amplifiers off and have the problem corrected later by your service engineer.

B. BETWEEN SHOWS

If the CP45 selected bypass itself and there are no LEDs alight in the buttons on the front panel. The shows will have to continue in bypass until the unit can be serviced; however, if manually selected bypass operation was required to complete a show and your preliminary checks suggest that the cause of a problem may be a fault within the CP45, you can take some further steps when you have more time between shows.

- If the indications are that the fault is in the CP45, perform the checks below after you have turned off the power amps to prevent loud thumps in the theatre.

- With the CP45 still in bypass, check the screw terminals at the back of the unit where the two power transformers connect, if any of the screws is loose, re-tighten and check **all** the other terminal block screws for tightness.

- Locate the four red LEDs at the front edge of the Cat. No.512 main board, (they indicate the status of the four main power supply voltages). Switch the CP45 from bypass back to normal operation, and watch what happens to the LEDs.

- If all four LEDs stay on steady, the power supply section of the Cat. No.512 is working properly. If any one of them is dim or out, the Cat. No.512 may be at fault, and, if available you should try substituting a spare Cat. No.512 or call your service engineer to correct the problem.

C. WHEN THE THEATRE IS CLOSED

If you can take the time, the following procedures may help you to track down which part of the CP45 may be the cause of the trouble. If you have to telephone your service engineer, the information you obtain can reduce the time required for him to correct the malfunction. Remember that you can still operate the system in **bypass**.

If the CP45 is one of several in a multi-screen theatre, temporarily substituting a board from another CP45 can help confirm your diagnosis. However, if you borrow a part from another unit, **do not change the positions of any of the preset controls or jumpers and be sure to replace it in the unit from which it came**. Nearly every module in the CP45 has been adjusted and jumpers have been programmed for its particular auditorium. Interchanging modules can result in poor sound or control errors.

D. TROUBLESHOOTING PROCEDURES

Trouble	Probable Cause	Recommended Action
No sound output. No LEDs lit. CP45 does not respond to commands.	No power to CP45	Check that the power blocks are firmly plugged into a live mains outlet of the proper line voltage.
No LEDS on the front panel are lit. Power LED's on front edge of the main board are **on**. There is sound.	Front panel board ribbon cable is unplugged.	Open front panel and plug back in the ribbon cable from the main board to its socket in the front panel board. The cable does not twist, it lies flat when plugged in.
No LEDS on the front panel are lit. Power LED's on front edge of the main board are **off**. There is sound.	Main board inside the CP45 is unplugged	Remove the main power block only from the mains supply, open the front panel and plug the main board back into it's socket in the backplane. Plug the main power block back into the mains outlet.
The CP45 locks in the bypass mode (the **bypass** LED flashes) regardless of any format command you select. There is sound.	Main power block not properly plugged in. Blown fuse.	The fuse on the main board is a 1 Amp slow blow and will blow only if there is a major malfunction in the CP45.

D. TROUBLESHOOTING PROCEDURES (cont'd)

Trouble	Probable Cause	Recommended Action
There is hum in the output. (You can detect hum coming from the booth speaker at normal listening level.)	Malfunctioning exciter lamp or lamp power supply.	Cover the solar cells with a business card or other opaque object. **Do NOT touch the cells and do NOT disturb the position of the cell bracket!** • If the hum disappears, the problem is in the exciter lamp.
	Stray light striking the stereo solar cells.	• If hum still persists, turn out all lights in the booth to check if stray light is striking the cells. If the hum disappears, turn on booth lights that are usually on during projection, one at a time, until you detect hum again. Redirect the light from the last source or keep it off during a showing. If the hum still is present, the problem is either in the grounding or wiring or in the CP45. Call service engineer.

D. TROUBLESHOOTING PROCEDURES (cont'd)

Trouble	Probable Cause	Recommended Action
All channels fail when playing a movie and Bypass does NOT bring the sound back.	Defective exciter lamp or lamp power supply.	Check that the exciter lamp is on and that the lamp power supply is operating. If not, fade up background music and transfer the reel to the alternative projector and continue the show there until the exciter lamp can be replaced. Call service engineer.
	Projector selection wire/switch is faulty.	If the front panel LED for the currently active projector is not alight, check that the projector selector switch wiring is held firmly under the screw terminals on the back panel of the processor and that the switch is operating properly.
	No signals coming from stereo solar cells.	Check that the signal present LEDs on the Cat. No. 222A/SR module under the main board are flashing while film is projected. If not, there is no signal from the solar cells or the Cat. No. 222A/SR has failed. Switch to bypass and call service engineer.
	Malfunction in the CP45.	If the signal present LEDs on the Cat. No. 222A/SR module are flashing, but the ones on the front panel are not, the problem is caused by a malfunctioning card or module in the CP45. Switch to Bypass and call service engineer.

D. TROUBLESHOOTING PROCEDURES (cont'd)

Trouble	Probable Cause	Recommended Action
One channel fails.	Defective power amplifier or wiring for that channel.	Place the CP45 in bypass. All three screen speakers should become active. If not, there is a fault in the power amplifier or wiring for the missing channel. Check if the amplifier concerned is on and check for blown fuses. Check that the wiring from the CP45 to the amplifier or the loudspeaker wiring have not been broken or disconnected; check that the screws connecting the wiring on the back panel are properly tightened.
	Malfunctioning module in CP45.	If the power amplifier and the wiring are satisfactory, the problem is a malfunctioning module in the CP45; Switch to bypass and call service engineer.

D. TROUBLESHOOTING PROCEDURES (cont'd)

Trouble	Probable Cause	Recommended Action
The sound from one channel is distorted (you can detect the distortion at the booth monitor at normal listening level).	Defective power amplifier for that channel.	Check if amplifier is on and if its fuse(s) is ok.
	Defective speaker for that channel. (Booth sound is OK but sound in the auditorium is bad).	Check speaker.
	Malfunctioning card in CP45.	Check that the supplies are present on the main board, (check the four supply LED's on the front lip of the main board). Check that the ribbon cable link to the front panel is properly in place. Check that the cards are all properly seated in their connectors, especially the 222A/SR module under the main board.
	Wiring from the stereo solar cell to the CP45.	Check that the wiring from the stereo solar cell to the CP45 has not become kinked and that the solder connections to the fanning strip are secure. Check that the fanning strip is firmly attached to the terminal strip on the CP45. Check that there is no other wire or screen connection touching the terminals for the cells on the back panel.
		Call service engineer.
The sound from two or more channels is distorted (you can detect the distortion at the booth monitor at normal listening level).	Malfunctioning 2-channel power amplifier.	If two distorted channels are served by the same 2-channel amplifier, the problem may be in the amplifier. See the manufacturer's instructions.
		Call service engineer.

D. TROUBLESHOOTING PROCEDURES (cont'd)

Trouble	Probable Cause	Recommended Action
When a stereo film is projected, the sound appears to be coming from the wrong speakers.	The A-chain has become misaligned.	Call service engineer.
You can hear pops and thumps during projector changeover.	If your projector changeover relay power is DC, a diode should be soldered across the winding of the relay to prevent noise from the relay winding from leaking into the audio wiring. This diode may be missing or defective.	If possible, check that the diode is installed across the relay winding. If you are familiar with such electronic components, check to see that it is not blown. If the diode is not present or if it appears to be blown, install a good diode. Activate the changeover and use a multimeter to find the polarity of DC that appears on the relay coil. Install the diode with the band end soldered to the terminal that is positive when measured with the meter.The diode should be a 1N4004 (1 Amp, 400 V), or a 1N4008 (1 amp, 800 V diode) or equivalent.
	If your projector changeover relay is AC, a capacitor soldered to the relay coil terminals may be defective.	Install a .01µF 600V capacitor to the relay coil terminals.
	Malfunctioning Cat. No. 514 optical preamplifier card.	Call service engineer to correct the malfunction.
Sound from the front (screen) channels is leaking into the surround channel.	The A-chain has become misaligned.	Call service engineer.
	Surround sound delay set improperly.	Call service engineer.
	Surround sound level set too high.	Call service engineer.

D. TROUBLESHOOTING PROCEDURES (cont'd)

Trouble	Probable Cause	Recommended Action
You hear an echo in a small theatre.	Surround sound delay set improperly.	Call service engineer.
The sound level in bypass is higher or lower than the normal sound level.	Adjust with the front panel fader since other parts of the system may be malfunctioning.	Call service engineer.
There is distortion when you play non-sync sound, but sound from the film is not distorted.	The non-sync source is introducing distortion. Malfunctioning Cat. No. 512 main board.	Change the non-sync selection in case the track being played is distorted. If you have control of the output level of the device (gramophone, cassette deck, CD player, etc.) it will be useful to turn down its volume especially if you have to operate the non-sync with the fader a long way below 7. If this does not help, try a different device. If the distortion goes away, you have found the problem. If changing both the device and the selection does not eliminate the distortion, the problem is in the CP45. Call service engineer.
Sound from a mono film is distorted but stereo film sound is ok.	Incorrect setting of Dolby Tone.	Readjust Dolby Tone level. Call service engineer.
Sound from a mono film is distorted as is sound from the center channel of a stereo film.	Malfunctioning power amplifier. Malfunctioning loudspeaker.	Interchange power amplifiers to determine if distortion is still present. Interchange speakers to determine if distortion is still present.

D. TROUBLESHOOTING PROCEDURES (cont'd)

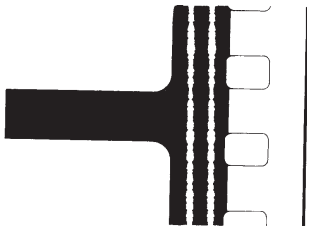
Trouble	Probable Cause	Recommended Action
Projector changeover command does not change to sound output of the selected projector and the front panel LEDs do not light according to the projector selected.	Defective changeover relay or switch.	If possible, check that the relay or switch contacts actually open and close as the changeover command is issued several times.
	Defective wiring from relay or switch to terminals on rear of the CP45.	Check that the wiring has not been damaged and that connections are firmly made at both ends.
	Malfunctioning Cat. No.510 optical preamplifier.	Call service engineer.
The sound output of the CP45 is at a medium level, regardless of the setting of the fader control.	Fader connector unplugged from CAT No 510 optical preamp board.	Plug fader connector back into the 2 pin connector towards the front of the left hand side board. It can only go one way round.
	Open circuit in fader circuitry.	Call service engineer.
When you select the local fader, there is no output from the CP45; all LED indications are proper; remote fader operation is OK.	There is a short on the fader wiring to the front panel potentiometer.	Call service engineer.
When you select the remote fader, there is no output from the CP45; all LED indications are proper; local fader operation is OK.	Defective wiring from remote fader to CP45.	Check the wiring for damage or breaks. Check that all connections are firmly made.
		Call service engineer.
	Short circuit on the remote fader.	Repair or replace remote fader.

D. TROUBLESHOOTING PROCEDURES (cont'd)

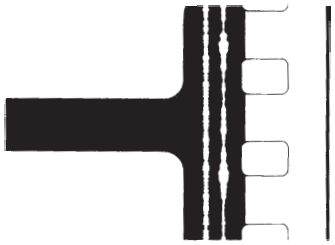
Trouble	Probable Cause	Recommended Action
You cannot change from local to remote fader operation.	The remote control is not plugged in.	Plug in remote control or check the wiring to see if any of the lines are open. Call service engineer.
The CP45 will only select Mono or the non-sync/aux formats. If either Dolby Stereo format is selected, the LED does not stay on when the button is released.	Missing or unplugged CAT222A/SR module.	Switch to bypass, open front panel, unplug ribbon to front panel and check that the Cat No. 222A/SR module is securely plugged into the rear panel. Plug the ribbon cable to the front panel back in securely and close the unit.
The CP45 will select formats but the sound does not change between them.	The unit is in bypass (bypass LED on front panel flashing).	If bypass switch is in the up position, set it to the down position. There is about 3 seconds delay, then the LED stops flashing and the format selection will work normally. If the bypass switch is in the down position but the LED is still flashing, call the service engineer.
With optional automation connected to the CP45: The CP45 freezes into one format and does not latch any selected format or other types of commands when you press the front panel switches.	Incorrect wiring to D-connector plugged into CP45.	Unplug the D-connector from the back of the CP45. If you can exercise local control over the CP45, the problem is in either the Cat. No. 511, the wiring to the automation equipment, or the automation equipment. Call service engineer. If you cannot exercise local control over the CP45 even with the automation equipment disconnected from the CP45, switch to bypass and call service engineer.

APPENDIX A
HOW TO TELL A STEREO OPTICAL PRINT FROM A MONO PRINT

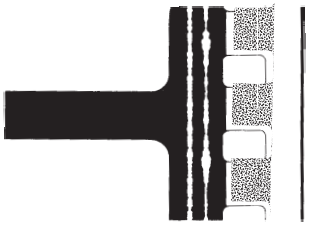
A Dolby encoded optical print should be identified as such on both the film can and leader. However, with handling the identification may be lost. If you are not sure if you have a stereo print, play a reel and find a section with music and / or effects only (on dialogue or narration, stereo soundtracks look much the same as mono soundtracks). Examine the soundtracks closely; on music and effects, the two soundtracks will appear to be different on a stereo print; on a mono print they are identical. Alternatively, while the film is playing, open the front panel and check the signal-present LEDs; the left, center, and right LEDs will flicker regularly if the print is stereo; the center LED will predominate if the print is mono. If you specified a stereo print and received a mono print in error, be sure to check with your local exchange or the film distributor.



Mono Print
Both tracks are the same.



Analog Stereo Print
Clear differences between channels will be seen in some places along the track.



DolbyDigital Print
The digital data is clearly visible between perforations next to the analog track. The analog track is Dolby SR.

Mono, Stereo, and Digital Soundtracks

There is no way to tell by visual inspection if a stereo print has been encoded with a surround channel. However, all but a few early Dolby Stereo releases do have a surround channel so, in general play any stereo print in format 04 Dolby A-type.

APPENDIX B
DOLBY TEST AND DEMONSTRATION FILMS

Several test and demonstration films produced by Dolby Laboratories are available from your equipment supplier. For proper system maintenance, the Cat. No. 69T test film is required and the Cat. No. 251 Jiffy Test Film is strongly recommended. The Cat. No. 69T test film should be formed into endless loops for ease of use. The eight-minute color short "***listen . . .***" (Cat. No. 351) is an excellent way to demonstrate in an entertaining way your commitment to a quality presentation. Three test films, Cat. Nos. 69N, 97, and 151, are for use only by a trained engineer with special test equipment; they are mentioned here so you know what they are should you ever come across them.

Cat. No. 69T: Dolby Tone

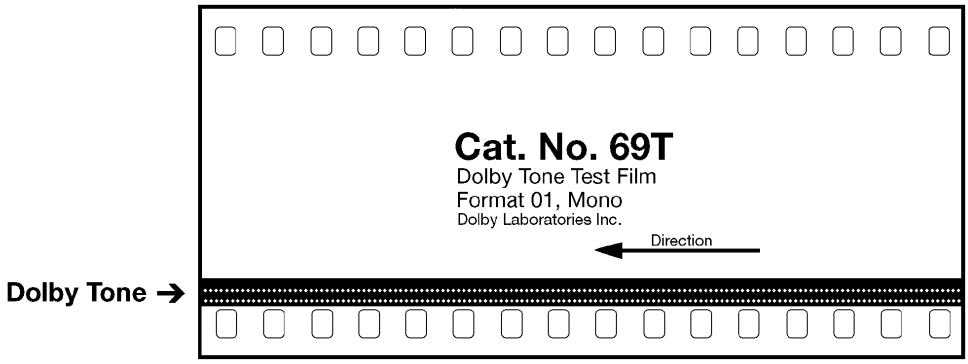
This film is required to maintain your theatre system. The Dolby Tone recorded on the film is for adjusting Dolby Level as instructed on page 2-2; this simple adjustment must be performed whenever an exciter lamp is replaced and should also be performed from time to time to compensate for the normal aging (and reduced light output) of exciter lamps.

Cat. No. 251: Jiffy Test Film

This eight-minute test film is strongly recommended to help keep your system sounding its best. No special equipment is required because the tests have been specifically designed to permit subjective judgment by ear. Each test is described by either a male or female voice and is supplemented by captions on the screen which help identify the causes of sound system problems. Visual checks are also included to assist in identifying some picture projection problems.

Tests provided on the Cat. No.251 include: Level Set, Channel Identification, Channel Level and Loudspeaker Equalization, Loudspeaker and Amplifier Condition, Projector Wow and Flutter, Overall System Performance, Visual "Quick-checks," and a Noise and Interference Test.

Duration:	8 minutes
Picture format:	35mm color, can be screened either 1.85:1 wide-screen or 2.35:1 anamorphic
Sound format:	04 Dolby Stereo A-type



Cat. No. 69T Dolby Tone Test Film

Cat. No. 251 Jiffy Test Film

Cat. No. 351 “listen . . .” Film

Test and Demonstration Films

Cat. No. 351 Stereo Demonstration Film: *"listen . . ."*

"listen . . .", an eight-minute Dolby Stereo demonstration film for public exhibition, has been professionally produced to demonstrate the commitment of the theatre to providing its audiences with the best in both sound and picture. It is intended for screening prior to a feature and is a fast-paced, entertaining short which shows off a quality projection system to its best advantage. Thus, it serves to promote the experience which only the motion picture theatre can provide and which cannot be matched by home entertainment media.

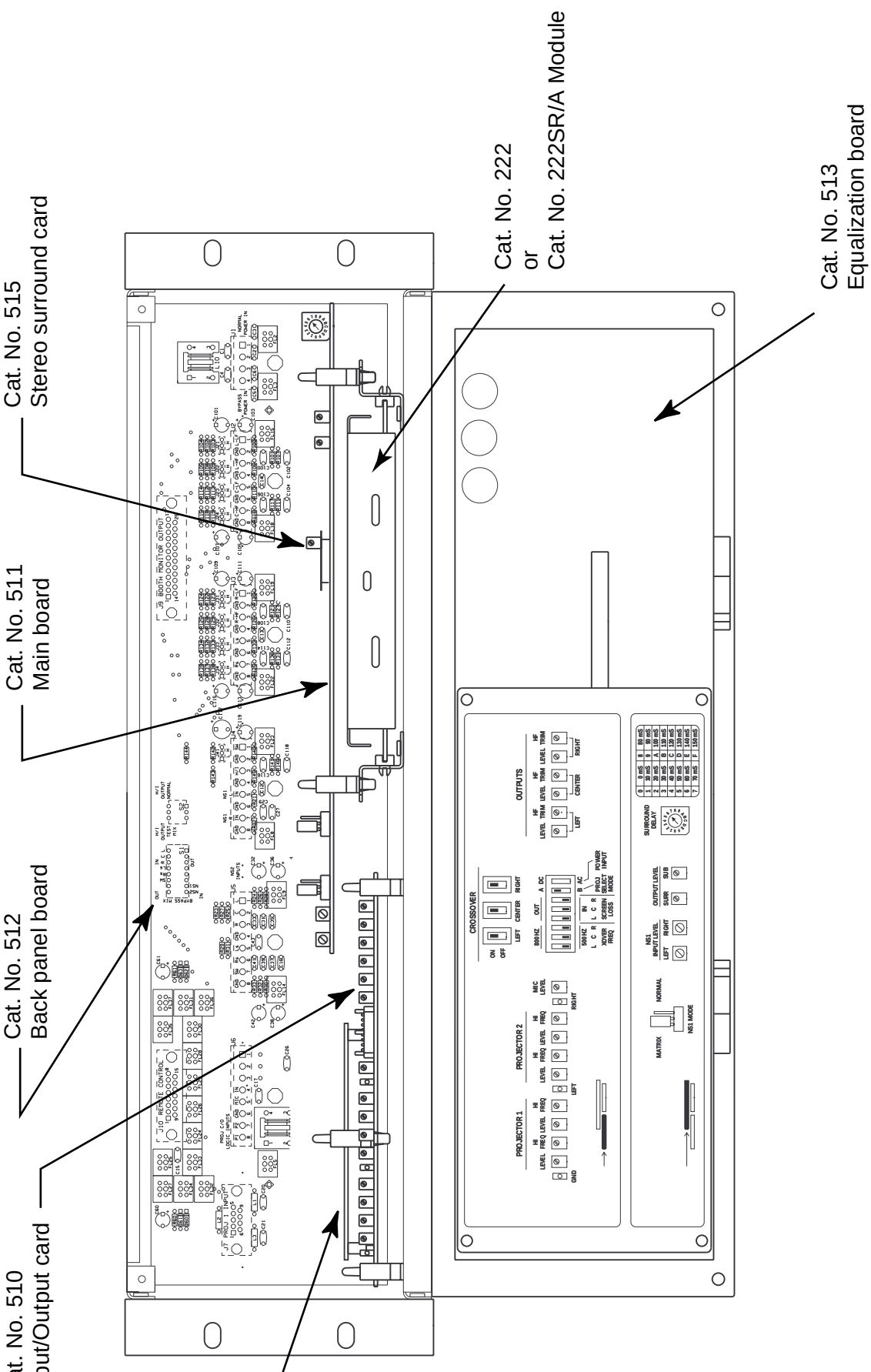
"listen . . ." has no narration and no sales or technical message except that implied by the quality of its presentation in the theatre. It consists of a wide variety of short scenes, both live action and an animation sequence, integrated into a unique sight and sound experience which bears repeated viewing. Because there were none of the plot constraints of a conventional feature, scenes were chosen specifically to demonstrate different aspects of stereo sound— from a trickling brook to a cannon salute, from a string quartet to a church organ, from the sounds of children at play to the thundering lift-off of a Saturn 5 rocket.

To ensure quality at least equivalent to the feature likely to follow it in the theatre, Dolby Laboratories engaged professional film craftsmen, including several Academy Award winners, to produce ***"listen . . ."***.

Running time:	8 minutes
Picture format:	35mm color, 2.35:1 anamorphic
Sound format:	04 Dolby Stereo A-type

Cat. No. 69P, Cat. No. 97, Cat. No. 151, and Cat. No. 566 Test Films

These specialized test films are for use only by trained engineers with special test equipment and need not be kept on-hand at the theatre. The Cat. No.97 is used for aligning stereo solar cells in projector soundheads, while the Cat. No.151 is used to set the level of the surround speakers relative to the screen speakers. The Cat. No.566 is used to measure the uniformity of light along the slit of the sound lens assembly in the projector.



Interior view of CP45 showing cards installed

APPENDIX C
CP45 MODULE DESCRIPTIONS

Cat. No. 510/514 Input/Output Card

The Cat. No. 510 is the input and output part of the CP45. It has two stereo inputs for optical soundtracks, one mono microphone input, and six outputs for the front screen speakers. The card is normally fitted with a Cat. No. 514 optical preamplifier card which converts the solar cell signals from the projectors into voltages which are handled by the Cat. No. 510.

This card also contains the power amplifier output stages for the front screen speaker channels.

Cat. No. 511 Main Board

The Cat. No. 511 main board carries all the circuitry for decoding Dolby A-Type and SR encoded film soundtracks. The unit also carries a power supply circuit which converts the low voltage AC supply from the external transformer into the various voltages used in the unit.

The board has all the logic switching for the various modes and carries the electronic volume control circuits for most of the outputs.

There is also a pair of inputs which can be connected video projectors etc. and which feed the Dolby decoder. This input can also be used for background and intermission music.

The board also carries the driver circuitry for the Cat. No. 222 or Cat. No. 222A/SR modules and the audio delay circuit for the surround channel.

If the unit is to be used with a large amount of mono material, there is a circuit which generates a pseudo-stereo output which tends to liven up such sources and enhance the reproduction of music.

Cat. No. 512 Equalization Board

The Cat. No. 512 board carries all the house equalizer controls for adjusting the acoustic response of the theater. There are seven 2/3 octave bands which cover the frequencies which cause most difficulty in loudspeaker systems.

The card also contains the controls for selecting the format of the film to be shown or for selecting background music etc.

Cat. No. 515 Stereo Surround Card

The Cat. No. 515 is a small board that is mounted on the Cat. No. 511 main board when stereo surround operation is desired.

Cat. No. 222 Module

This module provides two channels of Dolby A-type noise reduction for the soundtracks.

Cat. No. 222 SR/A Module

This module provides two channels of either Dolby A-type noise reduction or Dolby SR processing for the soundtracks.

APPENDIX D
ABOUT DOLBY FILM SOUND FORMATS

The application of Dolby A-type noise reduction to film soundtracks, as explained in Appendix G, "Cinema Sound and the Evolution of Dolby Stereo," had a major impact on cinema sound recording and reproduction. The later application of DolbySR has had still further impact. An understanding of how these systems work will help you better understand Dolby Stereo film sound in general, the CP45 in particular, and why the Dolby Level adjustment procedure is important in maintaining good sound in the theatre.

1. How Dolby Noise Reduction Works

Whenever sound is recorded — on magnetic tape, phonograph records, or film soundtracks — noise is added to the original signal. Dolby noise reduction keeps that added noise down to a minimum in a way that has no adverse effect on the quality of the original signal (e.g., it does not turn down the treble as filters do).

Dolby noise reduction is a two-step process used both at the time a recording is made and when it is played back. Just before the signal is recorded, it is processed by the Dolby noise reduction circuitry. Loud sounds which naturally hide noise are passed through unchanged. But quiet sounds which would be marred by added noise are selectively boosted (that is, they are recorded louder than normal). The resulting recording or film soundtrack is said to be "Dolby encoded." Both tracks on Dolby Stereo optical release prints are encoded in this way.

When the encoded recording or soundtrack is played back, it is decoded by Dolby noise reduction circuitry switched around to operate as a mirror image of the circuit used when the recording was made. Loud sounds again pass through unchanged. But the boosted quiet sounds are reduced in volume to where they were before they were recorded, a process which simultaneously reduces any noise added by the recording medium. The CP45 has two channels of Dolby A-type noise reduction and Dolby SR circuitry to decode the two soundtracks on Dolby Stereo release prints (the left, center, right, and surround channels are derived from the two soundtracks after the Dolby noise reduction decoding).

2. About Dolby SR

The soundtracks on Dolby Stereo SR prints have been encoded with the DolbySR (spectral recording) process, rather than Dolby A-type. DolbySR also boosts quiet sounds when a recording is played and brings them back down again when it is played back. However, the amount of boost it imparts is both greater and more selective than Dolby A-type. The result is more than twice the noise reduction, with the same freedom from side-effects Dolby A-type is noted for. In addition, Dolby SR incorporates further refinements which

enable the soundtrack to carry louder sounds with lower distortion and fewer signal losses. The result is a dramatic improvement in soundtrack dynamic range, that is, the volume range between residual film grain noise and the loudest sounds that can be recorded accurately.

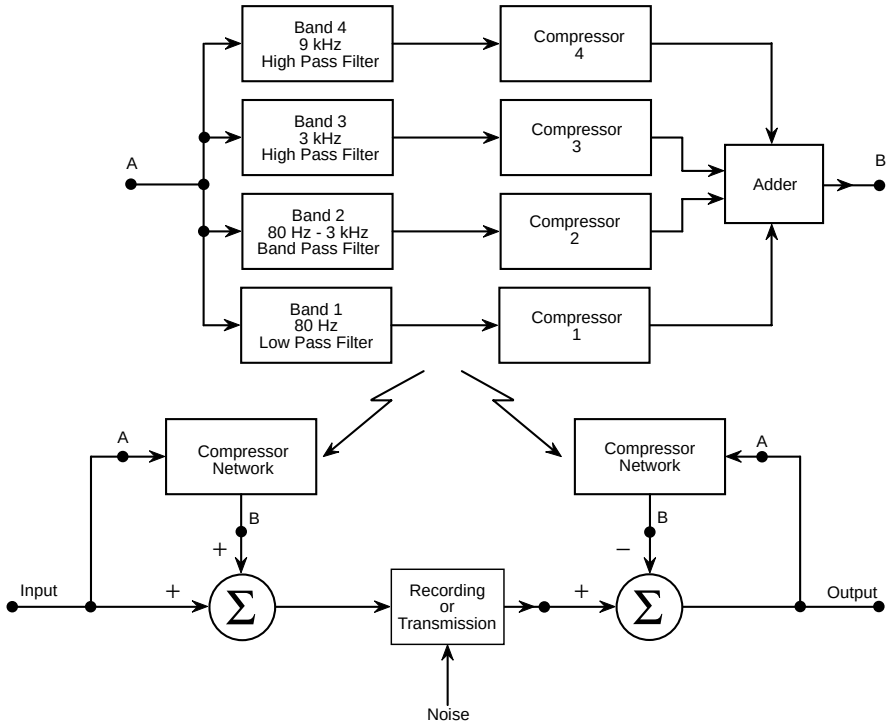


Figure D-1: Dolby A-type Noise Reduction Basic Block Diagram

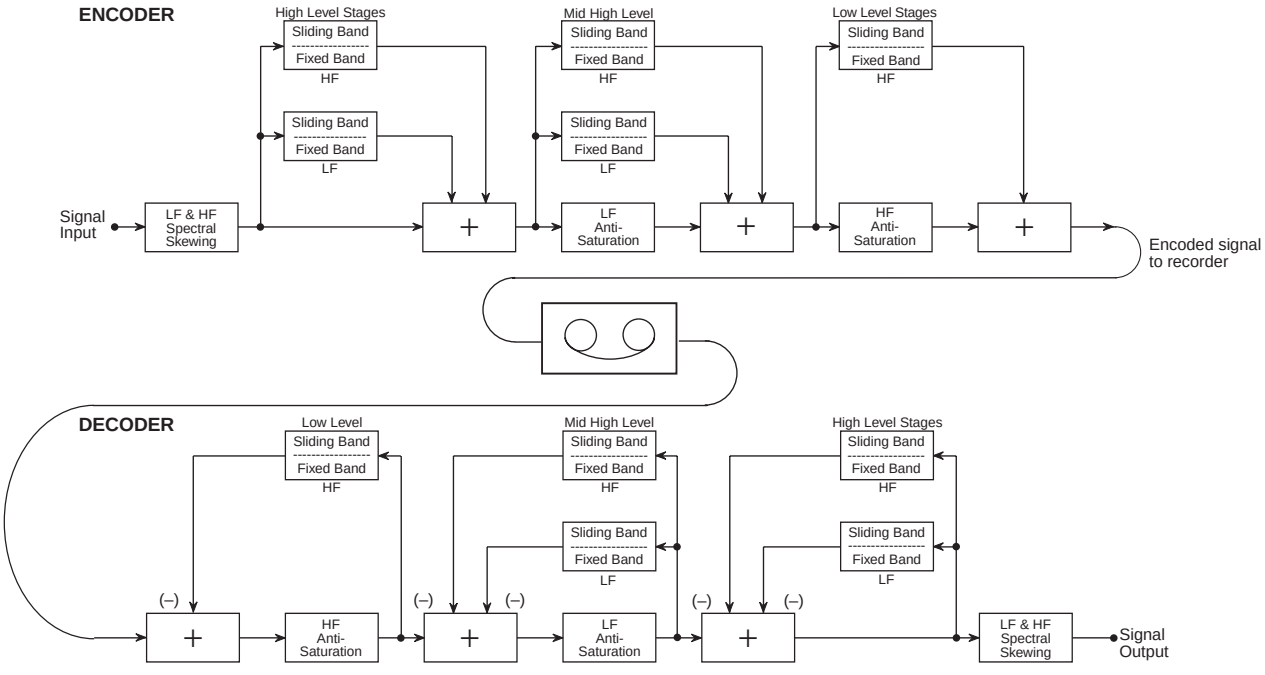


Figure D-2: Dolby Spectral Recording Encoder and Decoder Basic Block Diagram

3. Why Adjusting Dolby Level Is Important

The accurate reproduction of Dolby soundtracks requires that the decoders in the theatre act as precise mirror images of the encoders used when the tracks were recorded. This precision is ensured in two ways. First, Dolby system circuits are manufactured to very close tolerances. In fact, any A-type or SR circuit, regardless of when manufactured, can be connected back-to-back to any other circuit of the same type in an encode-decode configuration, and provide flat response within 1 dB. Second, a reference Dolby Level has been established so that any Dolby-encoded recording can be accurately decoded by any Dolby decoder of the same type.

Remember that Dolby circuit action in both recording and playback is level-dependent. Loud signals are untouched, while low-level signals are boosted during recording and attenuated during playback, by an amount that depends on their level. How does the playback Dolby decoder know when, and by how much, to attenuate the previously-boosted signals?

The answer is that it doesn't know. When the decoder sees any particular playback voltage, it *assumes* what happened when the recording was originally encoded. For that assumption to be accurate, however, it was necessary when Dolby noise reduction was first developed to establish a standard reference level to which all encoded recordings and all decoding circuits could be calibrated.

This is where the Dolby Level Tone on the Cat. No. 69 film comes into play. The tone on this film is very carefully recorded at the standard reference Dolby Level. When you make the Dolby Level adjustment on the CP455 as this film plays, you are making sure that the tone on the film is converted to a standard reference voltage at the inputs to the decoders. Thereafter, signals from Dolby soundtracks will be converted to the correct voltages for mirror-image decoding. As long as the proper Dolby Level procedures are followed, any Dolby-encoded soundtrack recorded anywhere in the world will be accurately decoded by any Dolby cinema processor anywhere in the world.

Although large level-matching errors can cause audible decoding errors (such as frequency response changes), both Dolby A-type and DolbySR are tolerant of errors smaller than about 2 dB. Thus, Dolby Level must be readjusted only if there is a significant change in the reproduction chain ahead of the Dolby decoding circuit. In the theatre, exciter lamp brightness is the variable most likely to affect Dolby Level calibration. The voltage present at the inputs to the decoder circuitry is directly proportional to the amount of light that passes through the slit and soundtracks onto the solar cell. Therefore, significant changes in exciter lamp brightness — likely as the lamp ages over time or when a new lamp is installed — should be compensated for by adjusting Dolby Level.

4. The Consumer Dolby Noise Reduction Systems

Dolby A-type noise reduction and DolbySR are used for professional applications, including music recording, broadcasting, and preparing film soundtracks. Other Dolby noise reduction systems—B-type, C-type, and S-type—have been developed for use in such consumer products as cassette recorders.

Dolby B-type was the first Dolby system developed for consumer applications, and is in use today in hundreds of millions of cassette recorders and other products (a modified version of B-type noise reduction is also used to encode the surround channel on Dolby Stereo and Dolby Stereo SR release prints). Dolby C-type was later developed to provide more noise reduction than Dolby B-type, and is provided along with B-type in many of today's high-performance consumer products. The newest consumer system, Dolby S-type, is based on some of the operating principles of DolbySR, and provides still more noise reduction. In addition, much like DolbySR on film soundtracks, S-type also improves a cassette recorder's high-level signal capability. The result on the newest decks with Dolby S-type is cassette performance subjectively equivalent to the Compact Disc.

These consumer systems systems differ from the professional Dolby systems in the type of noise reduction they achieve. Because they were developed for professional applications, Dolby A-type and DolbySR reduce all types of noise at all frequencies (low-frequency hum as well as high-frequency hiss). The Dolby B-type and C-type reduce the tape hiss which prevails in cassette recording; the circuits are considerably simpler and operate primarily at the higher hiss-related frequencies. Dolby S-type provides even more hiss reduction, and some noise reduction at low-frequencies as well.

APPENDIX E
HOW FOUR CHANNELS ARE DERIVED FROM DOLBY STEREO OPTICAL PRINTS

The 35-mm Dolby Stereo optical format calls for the recording in the studio and the reproduction in the theatre of four separate sound channels, — left, center, right, and surround — and yet a Dolby Stereo optical print has only two soundtracks. How is it possible to derive four channels of sound from only two soundtracks? The answer lies in the application of what are called phase matrix techniques for encoding four channels of sound onto two soundtracks, much like the four-channel phonograph records of the early 1970's.

There are two characteristics of sound which cue the brain to its origin and thus, its directionality. First is the amplitude or loudness of the sound. If the source of sound is directly in front of you, it arrives at both ears with equal loudness. But if the sound is located to the left, for example, the sound that arrives at your left ear is slightly louder then the sound that arrives at your right ear. This difference is processed by the brain so you recognize that the sound is coming from the left. Home stereo sound is based in great part on this principle; two channels on a recording that is reproduced on two speakers are sufficient for home listening to convey directional information all across a listening "stage" in front of you.

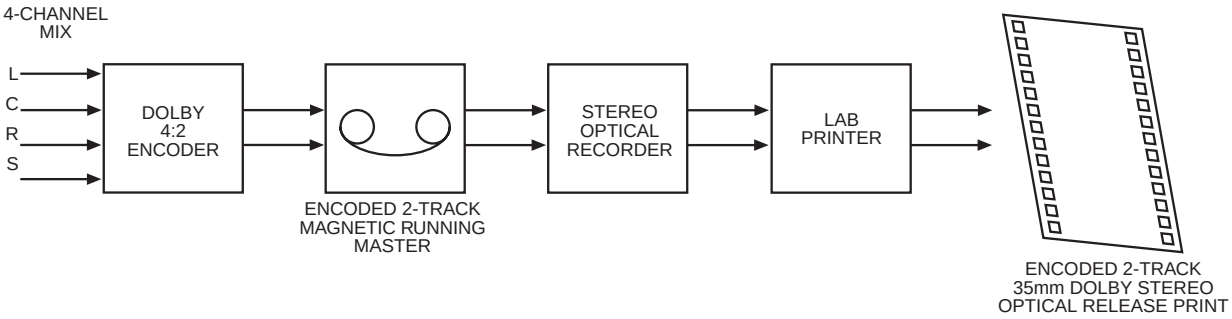
The other characteristic of sound which cues the brain to its directionality is phase. A sound coming from the left not only is louder when it arrives at your left ear but it arrives slightly earlier. That difference in timing results in what engineers call phase shift. The brain also processes that difference as a further directional cue.

The distinction between amplitude and phase as directional cues is not so important in conventional home stereo as in motion picture stereo. Movie theatres require more than two channels for good stereo sound. For example, in a theatre, left and right speakers are so widely spaced that sounds coming from the center (dialogue in particular) must be more firmly defined than in a home system. This requirement is met by the addition of a third, or center, channel and screen speaker. In addition, the use of a fourth channel toward the rear of the theatre is highly desirable to reproduce ambient sound for more life-like overall sound and to reproduce special directional effects. Thus, good theatre stereo requires a total of four channels.

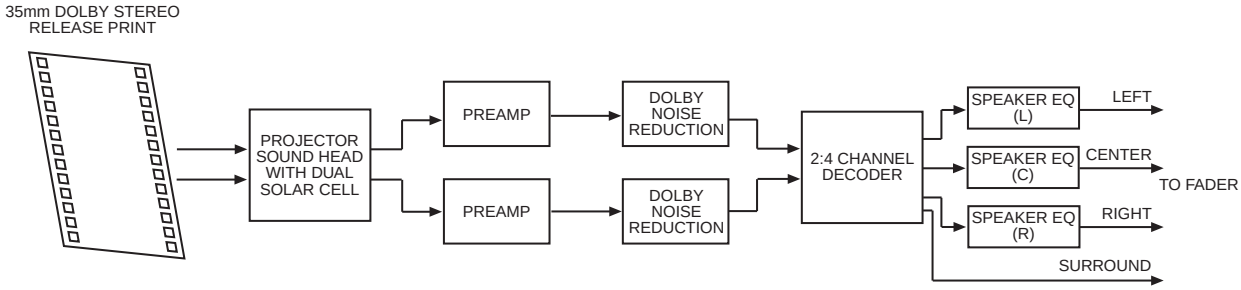
Dolby Laboratories developed a phase-matrix technique for encoding the four required channels of sound onto two tracks in exactly the same space as the conventional mono track. The final soundtrack is mixed to four discrete channels (left, right, center, and surround). Those four channels are then encoded to the two tracks which ultimately wind up on the release print. Basic left and right information is recorded unchanged onto the left and right tracks. Information which is to be reproduced in the theatre as a center channel — that is, sound which is identical in phase and amplitude — is split between and

recorded on both the left and the right tracks. And the surround information is also split between the two channels, but is recorded with a distinct phase shift to distinguish it from the left, center, and right information.

In the theatre, when the signals from the two tracks on a Dolby Stereo print reach the CP45 processor, its 2:4 decoder constantly compares the two signals. Those signal elements which differ primarily in amplitude are assigned to the left and right speakers. Those which are essentially identical in both phase and amplitude are assigned to the center speaker. And those parts of the signal which were recorded with the distinct phase shift are assigned to the surround speakers. To accomplish the decoding process effectively requires very sophisticated circuitry. That is why the 2:4 decoder within your CP45 is one of the most complex circuit cards. Feature films are produced using the Dolby phase-matrix technique as a reference. Only Dolby cinema processors can correctly decode these soundtracks the way they were intended.



a. Encoding



b. Decoding

Block Diagram, Dolby Cinema Stereo Encoding/Decoding

APPENDIX F
OPTICAL BASS EXTENSION

Dolby Laboratories developed the optical bass extension (OBE) circuitry for use with subwoofers — special bass loudspeaker units designed to provide the very low-frequency bass performance lacking in most conventional theatre speaker systems. (If your theatre is not equipped with subwoofers, consult your theatre equipment supplier for further information on how to take full advantage of optical bass extension.)

At first glance, it would appear appropriate just to add extra amplifiers and subwoofers to reproduce the lowest bass frequencies recorded on a soundtrack. Such an approach is insufficient and can even be detrimental to achieving realistic, natural sound. One problem is that at very low frequencies, there may not only be desirable music and effects information on the soundtrack, but there may also be hum and low-frequency print noise. Furthermore, reproducing very low bass in the theatre can excite resonances which add an artificial, boomy quality.

The optical bass extension circuitry is the vital link between the very low bass music and effects often recorded on wide-range Dolby Stereo prints and an installation that incorporates subwoofers and their associated amplifiers. The circuit is not merely a crossover network or a bass synthesizer; it extracts whatever low-frequency music or effects information is already recorded on the release print and, at the same time, rejects low-level hum and low-frequency optical noise. In addition, a sophisticated filter system (adjusted by the trained installer) assures natural low bass response without the boomy quality which would otherwise result from the interaction between low-frequency bass speakers and the theatre acoustics. The result is smooth, deep bass response which complements the improved mid and upper range response already achieved in your theatre by means of the equalization in the CP45.

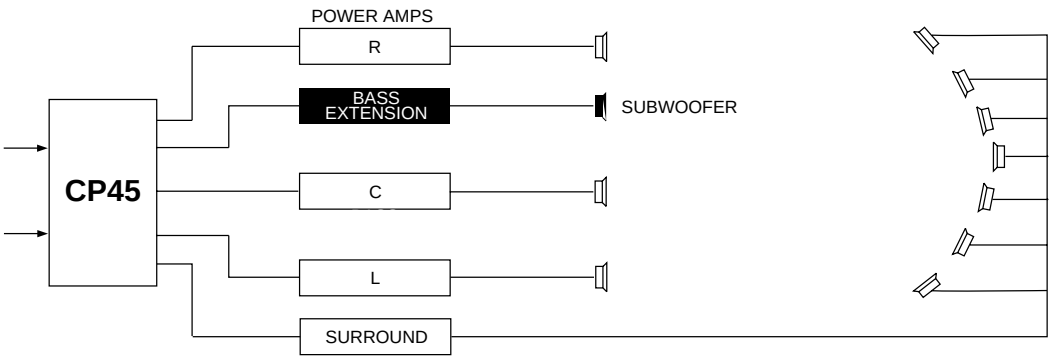


Figure F-1. Bass Extension Installation.

APPENDIX G
THE EVOLUTION OF DOLBY FILM SOUND

Thanks to such developments as multichannel sound, the motion picture viewing experience today is more exciting and involving than ever before. And what the audience hears today is very much the result of a continuing effort to improve film sound originally undertaken by Dolby Laboratories more than twenty years ago. Indeed, the evolution of motion picture sound over the past two decades is, in great part, that of Dolby film sound technologies.

Optical Sound

The photographic or "optical" soundtrack was the first method of putting sound on film, and today it remains the most popular.

An opaque area adjacent to the picture contains narrow, clear tracks that vary in width with variations in the sound. As the film is played, a narrow beam of light from an exciter lamp in the projector's soundhead shines through the moving tracks. Variations in the width of the clear tracks cause a varying amount of light to fall on a solar cell, which converts the light to a similarly varying electrical signal. That signal is amplified and ultimately converted to sound by loudspeakers in the auditorium.

Several advantages of optical sound have contributed to its universal acceptance, the foremost being economy. For one thing, the soundtrack is printed photographically on the film at the same time as the picture. For another, the soundtrack can last as long as the picture, which–with care–can be a long time indeed. A further benefit is that the optical soundhead within the projector is itself economical and easily maintained.

Motion pictures with sound were first shown to significant numbers of movie-goers in the late 1920s. By the mid-1930s, the "talkies" were no longer a novelty, but a necessity, and many thousands of theaters were equipped in that short time to show films with optical soundtracks. This phenomenally rapid acceptance of a sophisticated new technology was not without drawbacks, however. Equipment was installed in theaters so rapidly that there was no time to take advantage of improvements which were occurring on an almost daily basis.

A good example is loudspeaker design. The first cinema loudspeakers had very poor high-frequency response. Speakers with superior high-frequency capability became available within just a few years. But there was no time to retrofit the original systems with new units, because engineers were too busy equipping other theaters with their first sound installations.

This caused a dilemma for soundtrack recordists. Should the tracks be recorded to take advantage of the improved speakers, or should they be prepared to sound best on the many older installations already in place? Given that it was impractical to release two versions of a given title, the only alternative was to tailor soundtracks to the older speakers. The result was to ignore the improved high-frequency response of the newer, better units.

To forestall compatibility problems, in the late 1930s a *de facto* standardization set in, the theater playback response that today is called the "Academy" characteristic. Theater owners knew what to expect from the films, and therefore what equipment to install. Directors and sound recordists knew what to expect from theater sound systems, and thus what kind of soundtracks to prepare. The result was a system of sound recording and playback that made it possible for just about any film to sound acceptable in any theater in the world. It was also a system, however, without the flexibility to incorporate improvements beyond the limitations that existed in the 1930s.

Even with these limitations, for years optical film sound provided higher quality sound than home phonographs and radios. But by the late 1960s and early 1970s, superior hi-fi stereo systems had been installed in so many homes that a significant and influential proportion of the moviegoing public was used to better sound at home than could be heard in the theater.

Magnetic Sound

In the 1950s, a new method of putting sound on film was introduced as an alternative to the optical soundtrack. After the picture is printed, narrow stripes of iron oxide material similar to the coating on magnetic recording tape are applied to the film. The sound is then recorded on the magnetic stripes in real time. In the theater, the film is played back on projectors equipped with magnetic heads, similar to those on a tape recorder, mounted in a special soundhead assembly called a "penthouse."

Magnetic sound was a significant step forward, and at its best provided much improved fidelity over the conventional optical soundtrack. Magnetic sound also permitted the multiple tracks required by stereophonic sound. The voice of an actor appearing to the left, center, or right of the picture could be heard coming from speakers located at the left, center, or right of the new wide screens also being introduced at this time. Music took on a new dimension of realism, and special sound effects could emanate from the rear or sides of the theater. The two main magnetic systems adopted were Twentieth Century Fox's four-track 35 mm CinemaScope system introduced for *The Robe*, and the six-track Todd-AO system first used for such 70 mm films as *Oklahoma!* and *Around The World in 80 Days*.

Many theaters were equipped for magnetic sound in the 1950s, even though the playback equipment was expensive. Many films were issued with magnetic soundtracks, although magnetic prints were, and remain, much more expensive than optical sound prints (35 mm magnetic prints cost at least double their optical equivalents, and today's 70 mm magnetic prints cost up to fourteen times as much).

By the 1970s, however, the film industry declined overall, with fewer films and fewer theaters. The expense of magnetic release prints, their comparatively short life compared to optical prints, and the high cost of maintaining magnetic theater equipment led to a massive reduction in the number of magnetic releases and theaters capable of playing them. Magnetic sound came to be reserved for a only handful of first-run engagements of "big" releases each year. By the mid-1970s, movie-goers were again usually hearing low fidelity, mono optical releases again, with only an occasional multitrack stereo magnetic release.

Dolby Gets Involved

The situation that prevailed in the mid-1970s completely changed by the late 1980s. Thanks to new technology and a turnaround in the financial decline of the industry, almost all major titles today–accounting for 80% of the boxoffice–are released with wide-range multichannel stereo soundtracks.

The breakthrough was the development of by Dolby Laboratories of a highly practical 35 mm *stereo* optical release print format originally identified as Dolby Stereo. In the space allotted to the conventional mono optical soundtrack are two soundtracks that carry not only left and right information as in home stereo sound, but also information for a third center-screen channel and–most notably–a fourth surround channel for ambient sound and special effects.

This format not only enabled stereo sound from optical soundtracks, but higher quality sound as well. Various techniques are applied both when the soundtrack is recorded and when it is played back to improve fidelity. Foremost among these is Dolby noise reduction to lower the hissing and popping associated with optical soundtracks, and loudspeaker equalization to adjust the theater sound system to a standard response curve.

All this means that these prints can be reproduced in theaters with Dolby-manufactured cinema processors with far wider frequency response and much lower distortion than conventional soundtracks. In fact, the Dolby optical format has led to a new worldwide playback standard (ISO 2969) for wide-range stereo prints, just as the "Academy" characteristic applies for mono prints.

An important advantage of the Dolby optical format is that the soundtracks are printed simultaneously with the picture, just like mono prints. Thus a four-channel stereo release print costs no more to make than a mono print (although it is more expensive to record and mix in stereo than in mono). Conversion to Dolby optical is relatively simple–more than 28,000 theaters worldwide have done so–and, once the equipment has been installed, very little maintenance is required, particularly when compared to magnetic stereo playback systems. Moreover, print life is as long as that of conventional mono optical prints, unlike magnetic prints. The result is multichannel capability equaling that of four-track magnetic 35 mm (made all but obsolete by the stereo optical format), consistently higher fidelity, and few of the drawbacks of magnetic formats.

Much of the new technology, including noise reduction and equalization, also is applied to 70 mm magnetic releases (also originally designated as Dolby Stereo). Although 70 mm release prints continue to be very expensive, Dolby improvements brought a resurgence of interest in this "big" format for road shows where the ultimate in picture and sound presentation is particularly likely to be reflected in box office figures. There are six magnetic tracks on 70 mm film, two of which carry low bass effects. Some 70 mm films also use a technique developed by Dolby Laboratories to provide two separate surround channels in addition to the left, center, right, and bass effects screen channels.

The Next Step: Dolby SR

In 1986, Dolby Laboratories introduced a new professional recording process called Dolby SR (spectral recording). Like Dolby noise reduction, it is a mirror-image, encode-decode system used both when a soundtrack is recorded and when it is played back. It provides more than twice the noise reduction of Dolby A-type, and, moreover, permits capturing loud sounds with wider frequency response and lower distortion.

35 mm optical soundtracks treated with Dolby SR instead of Dolby A-type not only sound superb in the more than 10,000 theaters equipped with special SR processors, they also play back satisfactorily in *any* theater. As a result, most Dolby SR titles are released single inventory. In fact, in theaters equipped with regular A-type processors, the moderate compression that results helps prevent the louder peaks on SR soundtracks from overloading the theater's sound system. This feature further obviates the need for separate mixes and releases.

And Now - Dolby Digital

The newest film sound development from Dolby Laboratories puts a six-channel *digital* optical soundtrack in addition to a four-channel SR

analog track on the same 35 mm prints. This Dolby Digital format is yet another significant step forward in film sound, providing independent left, center, right, left surround, and right surround channels, plus a sixth channel for bass effects.

In addition to multiple channels, the Dolby Digital track provides extraordinary dynamic capability, wide frequency, range low distortion, and relative immunity to wear and tear. The format has already proved its unique combination of high quality, reliability, and practicality in theaters around the world. And because the digital track is right on the film, the format has none of the drawbacks of separate disc systems.

As with previous Dolby developments, Dolby Digital does not obsolete existing theater installations. The prints can be played conventionally in any theater, while the digital optical track can be reproduced by adding digital readers to the projectors and a digital decoder which interfaces with the theater's existing Dolby cinema sound processor.

About Dolby AC-3

Conventional digital audio is coded by a technique called pulse code modulation (PCM). As good as it sounds, however, PCM-coded audio coded takes up so much more space than analog audio that it was necessary to invent an entirely new medium, the Compact Disc, to bring digital sound into the home.

It would be very difficult to provide even *one* channel of conventional PCM digital audio on a movie print, let alone the 5.1 channels widely regarded as ideal for proper cinema stereo. Yet for compatibility, ease of distribution, economical release print manufacturing, and overall cost-effectiveness, nothing beats the classic, on-film optical soundtrack.

Therefore, to make it possible to put a *digital* optical soundtrack on release prints, Dolby Laboratories developed with a new, far more efficient way to code digital audio, a technique which provides 5.1 channels of sound in less space than just one channel on a CD. This new technique is called Dolby AC-3.

Just like the Dolby Surround technology developed originally for motion picture sound, Dolby AC-3 can be used in a wide variety of other applications, including consumer formats. For example, AC-3 will be used to provide 5.1 channel surround sound with the U.S. HDTV system and digital video discs. It is already being used on compatible Laser Discs of movies, including many originally released in the Dolby Digital format. Equipment for home Dolby AC-3 playback has come onto the market as well.

Making Films Sound Better

Dolby format release prints and the equipment which reproduces them are only links in a chain that extends from the original location, through the dubbing theater, to the laboratory, and finally into the theater. Developments like Dolby SR and Dolby Digital ensure that the soundtrack itself remains one of the strongest links. But just like high-quality CDs played on the best home stereo equipment, Dolby formats are capable of carrying a higher fidelity "message" than previously–and so can reveal the quality of each step in the recording, mixing, and dubbing processes. Taking advantage of the new formats has thus required new approaches to soundtrack production. Admittedly, the results can vary–the final reproduced soundtrack can be no better than the elements it comprises–but Dolby film sound at its best means not only better quality sound, but sound in the theater that consistently realizes the director's original intentions.

While Dolby's involvement with film sound first achieved wide recognition with the spectacular audio effects of such films as *Star Wars*, it has long since come to mean more than just special or dramatic effects. The objective is high quality sound reproduction overall–dialogue and music, as well as effects. Dolby technology is a means, not an end. It can be likened to an artist's palette that provides the director with a full range of colors, where before there were but a few. Above all, Dolby formats have been developed to enhance that very special experience of going to the movies.